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## USAAVLABS TECHNICAL REPORT 68-37

# DEVELOPMENT AND TEST OF AN AUTOMATIC-SHUTOFF CLOSED-CIRCUIT REFUELING SYSTEM FOR THE UH-1 HELICOPTER

By

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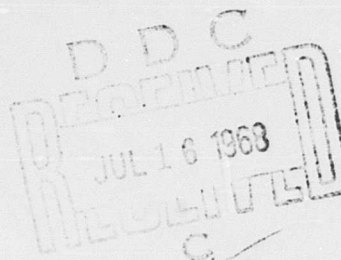
March 1968

**U. S. ARMY AVIATION MATERIEL LABORATORIES  
FORT EUSTIS, VIRGINIA**

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March 1968

DEVELOPMENT AND TEST OF AN AUTOMATIC-SHUTOFF  
CLOSED-CIRCUIT REFUELING SYSTEM FOR THE UH-1 HELICOPTER

Final Report

By

Francis V. Limandri  
Leonard M. Bartone

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## SUMMARY

An in-house program was conducted by the U. S. Army Aviation Materiel Laboratories (USAAVLABS) to derive a method for rapid refueling of Army helicopters. The objective was to devise a system which would permit refueling of helicopters while engines and rotors were operating without the risk of fuel contamination or fire. A closed system utilizing a dry-break coupling between fuel hose nozzle and aircraft was deemed to offer potential.

Experimental models were fabricated and tested, and modifications were made to the models in areas where test results indicated that deficiencies existed. Tests and modifications continued until design characteristics for a prototype model were finalized. Design characteristics are as follows:

1. Automatic-shutoff device.
2. Quick-connect/disconnect dry-break coupling between aircraft adapter and nozzle.
3. Conventional refueling capability.
4. Simplified system for field retrofit.

Ten prototype units were fabricated for military potential test purposes. The tests, which were conducted by the U. S. Army Aviation Test Board at Fort Rucker, Alabama, showed that the automatic-shutoff closed-circuit refueling system has military potential and will meet the program objective.

It is concluded that the effectiveness of helicopters as assault vehicles can be improved through the use of this system.

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## INTRODUCTION

### BACKGROUND

The conventional over-the-wing method of refueling Army helicopters consists primarily of pumping the fuel from a bulk container into the aircraft tank system through a 3-inch filler neck opening, just as an automobile is refueled. The gap between the filler neck and the hose nozzle permits contaminants to enter the fuel tank and permits fuel vapors to emanate from the tank. Thus, during the refueling process, helicopter engines and rotors must be shut down to avoid the risk of contamination from the dust cloud generated by rotor downwash and to avoid the fire hazard created by fuel vapor.

The shutting down of engines and rotors during refueling gives rise to a problem that has particular significance in tactical situations: lengthy turnaround time. This problem has presented itself forcefully in the current conflict in Southeast Asia, where, for reasons of expediency, helicopter crews have been refueling with engines and rotors running, despite the risk involved. That the risk is a real one is verified by formal reports from the U. S. Army Board for Aviation Accident Research; in the past year, at least two major fires have occurred as a result of the refueling of UH-1 helicopters with engines running. Informal reports from Southeast Asia indicate that helicopter fuel tanks are accumulating excessive amounts of debris, thus requiring frequent cleanout.

The need for a solution to the problem was formally recognized in August 1963, when the Deputy Commanding General of the U. S. Army Mobility Command requested USAVLABS to evaluate a proposed method for "expeditious tactical refueling".

In the ensuing evaluation, it was determined that the proposed method, which included the use of 50-gallon externally mounted fuel cells, was impractical from an operational standpoint.

Solution of the problem pointed toward some type of closed-circuit system. It was foreseen that such a system, operating under low pressure, would permit helicopter refueling with engines and rotors operating. Therefore, the closed-circuit concept was deemed to be worthy of further research, and the effort reported herein proceeded on that basis.



## PRELIMINARY EXPERIMENT

An experimental closed-circuit refueling assembly was fabricated and tested to determine the feasibility of such a system for refueling helicopters. Figure 1 is a photograph of the original experimental unit. This unit provides a dry-break fitting that connects the fueling nozzle with the aircraft fuel filler neck and a fuel vapor vent line that runs from the filler neck to an area 30 to 40 feet away from the aircraft. This system was installed on a salvaged UH-1A helicopter fuel tank, and simulated refuelings were accomplished. Water was used in place of fuel for reasons of economy and safety. After several refuelings were accomplished, it was determined that a properly designed refueling system based on this concept would be feasible and economical.

## ESTABLISHMENT OF HOUSE TASK 65-25

This determination led to the establishment of a house task, the objective of which was to devise a closed-circuit helicopter refueling system which would permit refueling while engines and rotors were operating. Design characteristics were established based on the findings of the preliminary investigations.

Principal requirements were as follows:

1. Provide an automatic-shutoff device, since fuel level could not be observed. (To provide a fuel-level indicator would be complex and costly.)
2. Design the aircraft and nozzle adapters so that they are large enough to accommodate the full flow of a standard refueling nozzle.
3. Remove the vapor line from the filler neck adapter. (The incorporation of this line at the adapter made the adapter cumbersome and reduced fuel flow capability.)
4. Design a system that can accommodate a conventional refueling method.
5. Design a system that can be installed by organizational maintenance personnel.
6. Design a lightweight system.

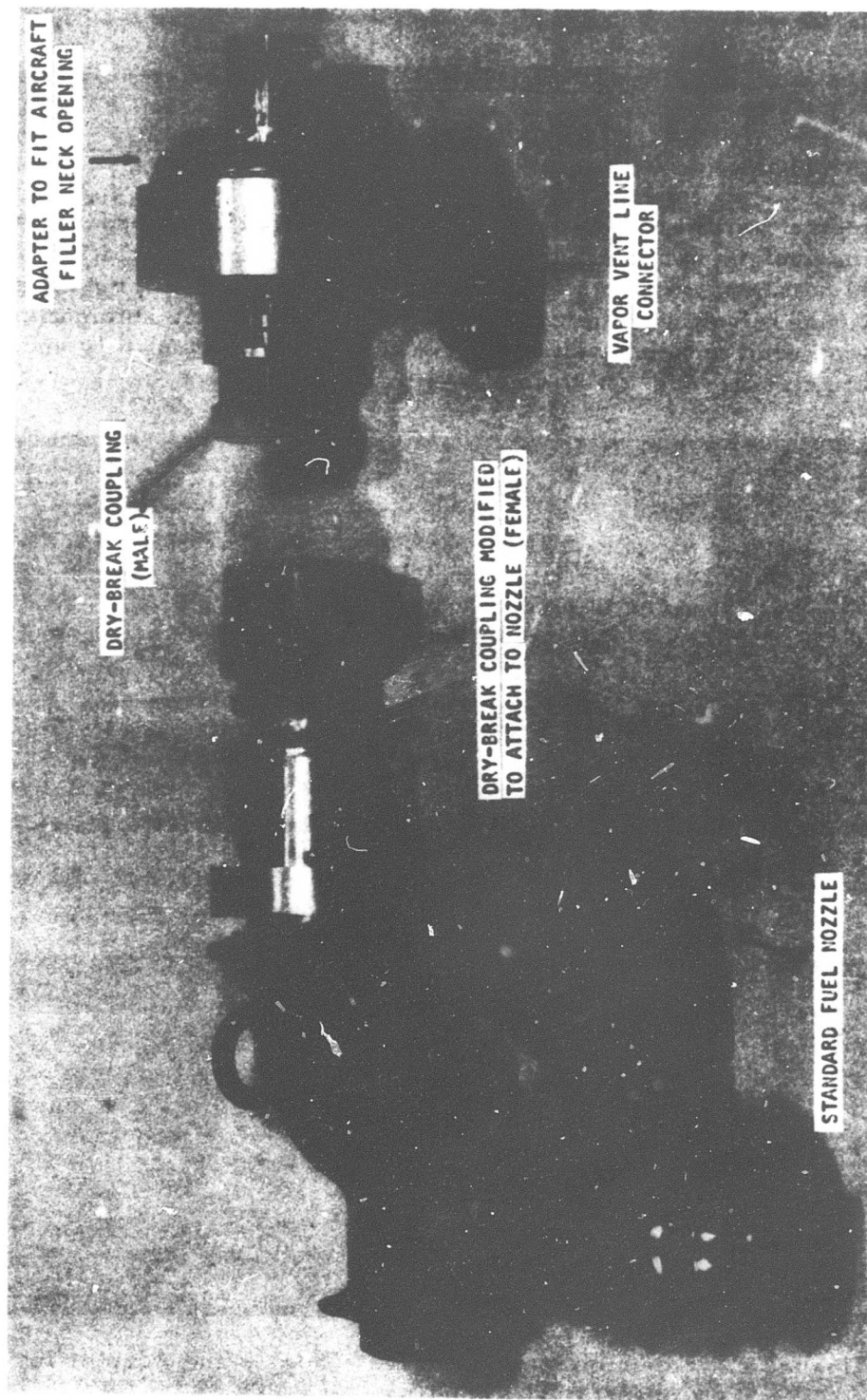


Figure 1. Preliminary Concept Unit.

## PRELIMINARY TESTS

### PREPARATION

Experimental hardware was designed and fabricated in accordance with the preceding design characteristics. Figure 2 shows the aircraft adapter and modified nozzles. Figure 3 shows the modified nozzle with the adapter for conventional refueling. An industrial filling-station-type automatic-shutoff nozzle was used in this assembly. A schematic of the fuel flow and the automatic closing mechanism is shown in Figure 4.

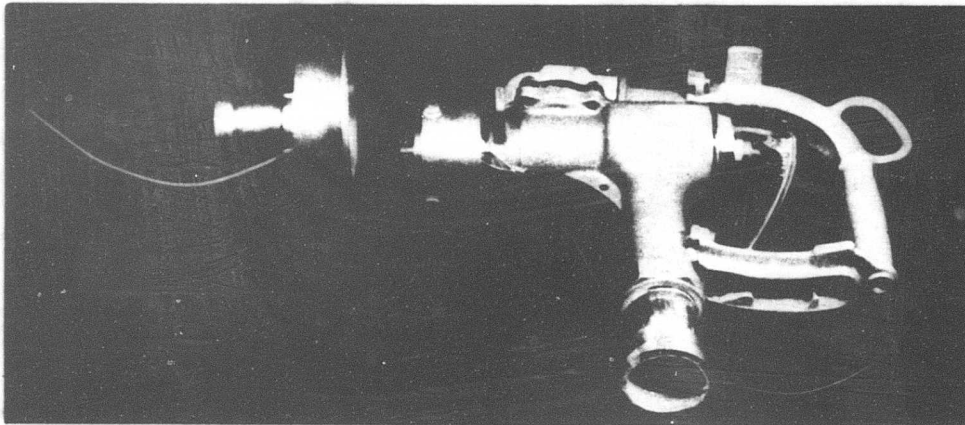


Figure 2. Experimental Hardware - Nozzle and Aircraft Adapter.

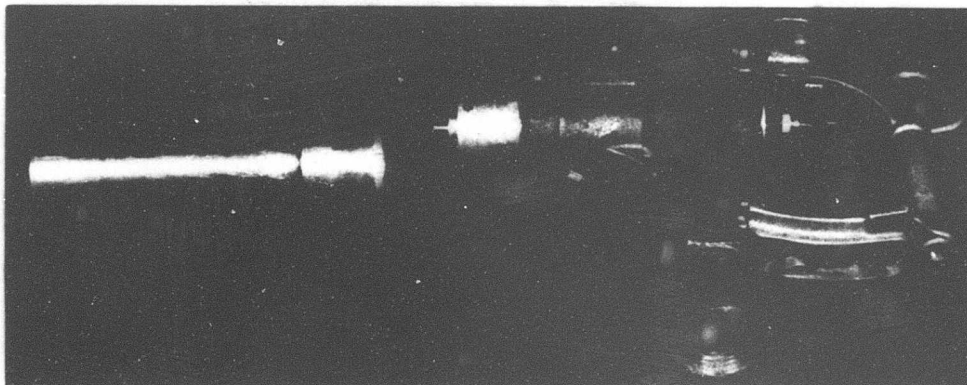
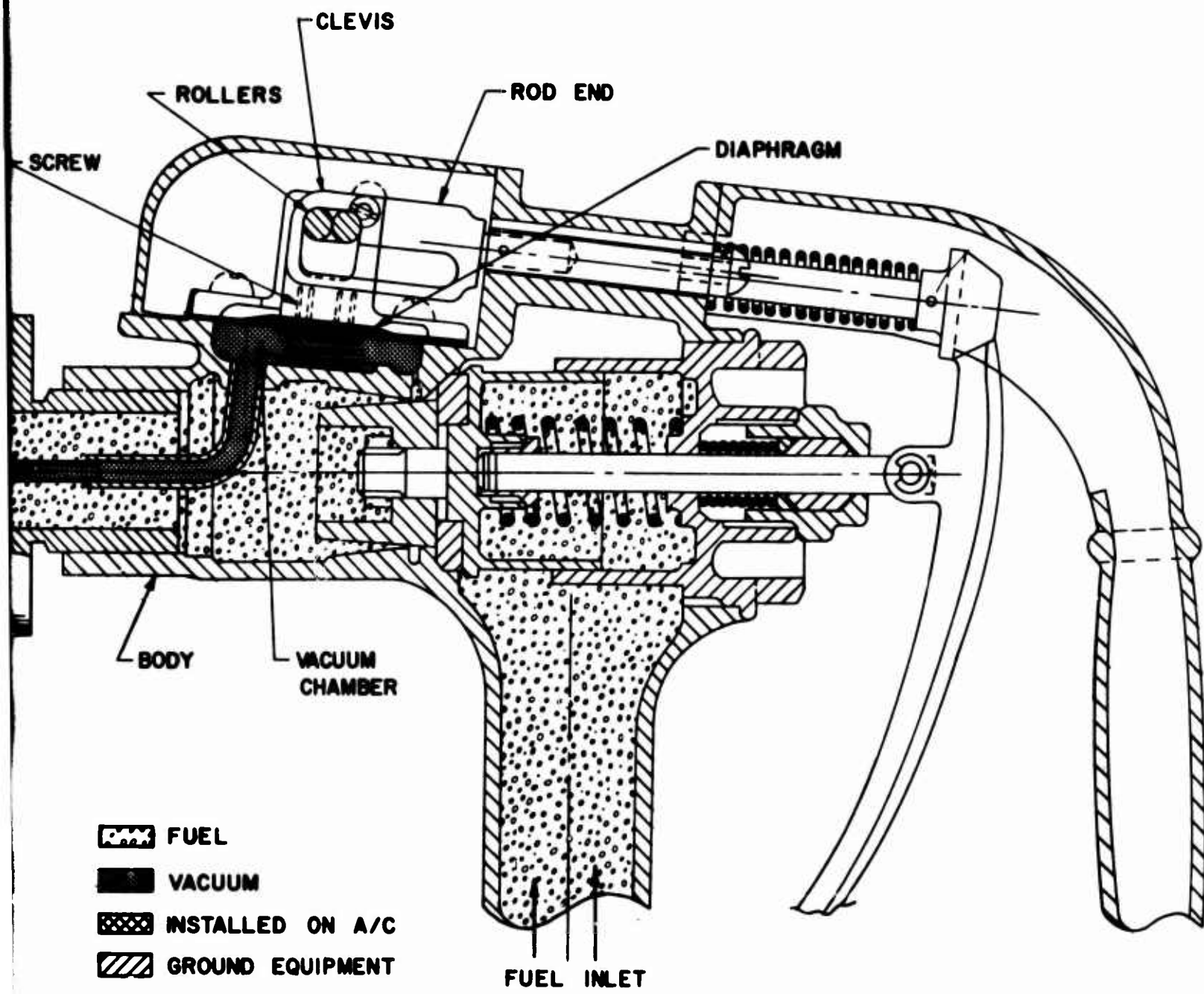


Figure 3. Experimental Hardware - Nozzle and Adapter for Conventional Refueling.





B

## REFUELING

The prototype unit was tested using a UH-1A helicopter and an M49C refueling truck. Installation of the aircraft adapter was accomplished by simply substituting the adapter for the conventional refueling filler neck assembly. The installed adapter is shown in Figure 5. The conventional nozzle was removed from the hose assembly, and the modified nozzle was installed in its place. Conventional refueling was accomplished by removing the inner assembly (nipple) of the adapter. Figure 6 shows the nipple assembly removed. Several refuelings were accomplished both with a closed system and with a conventional system. Each refueling with a closed system was initiated by mating of the nozzle and aircraft adapter and was terminated by removing the nozzle.

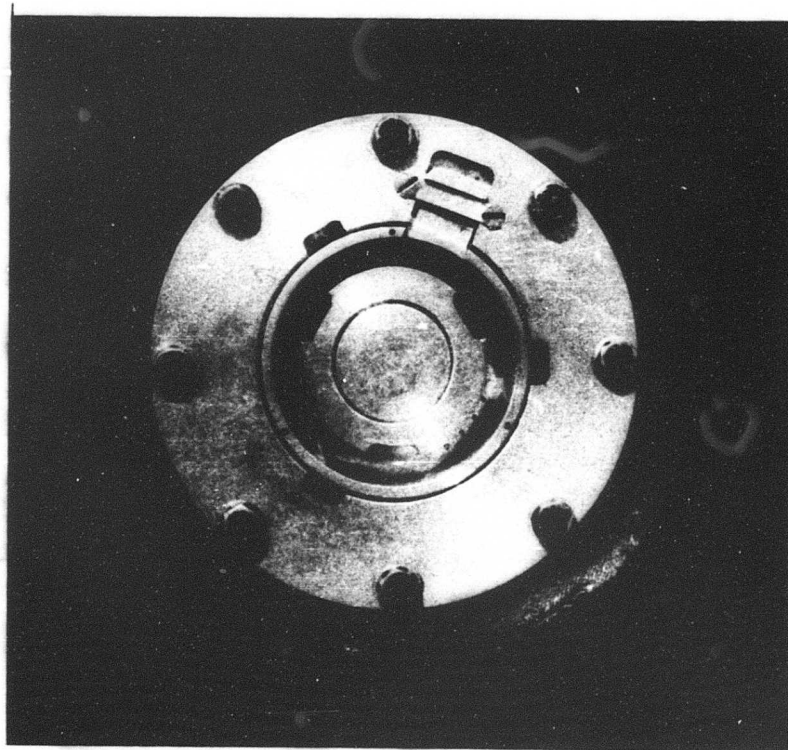
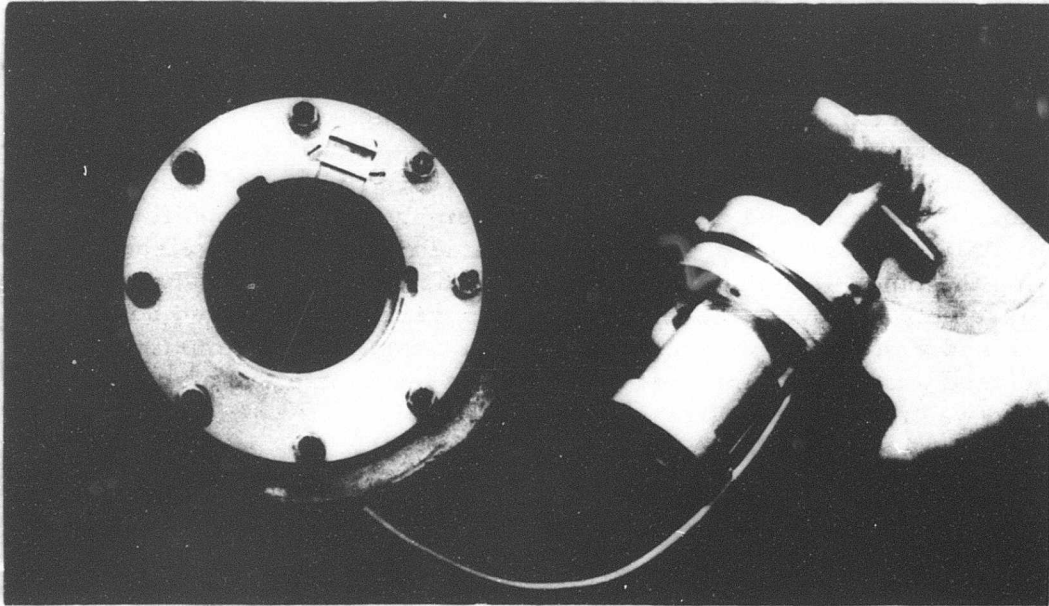


Figure 5. Experimental Hardware - Aircraft Adapter Installed.





**Figure 6. Experimental Hardware - Aircraft Assembly Nipple Removed.**

## **RESULTS**

No problems were experienced in the installation of either the aircraft adapter or the nozzle. No significant problems were encountered during the tests. No functional discrepancies occurred during the refueling cycles, and no malfunctions occurred during the engagements and disengagements of the adapter nozzle; however, the following undesirable features of the particular design were noted:

1. The quick-connect/disconnect feature was not "quick". The nozzle-hose unit was too heavy and cumbersome to allow use of a twist-type dry-break coupling connection. A single push-pull coupling would have been desirable.
2. A special tool was required to remove the closed-circuit system nipple assembly to allow conventional refueling. The loss of this tool would preclude conventional refueling.

It was determined that numerous modifications would be necessary to overcome these undesirable features of the system.

## MILITARY POTENTIAL TESTS\*

### PREPARATION

Prototype hardware which incorporated features designed to overcome the shortcomings of the experimental unit was designed and fabricated. An off-the-shelf push-pull quick-connect/disconnect dry-break coupling was modified to accommodate the requirements of the automatic-shutoff closed-circuit refueling concept.

### Description of System

The automatic-shutoff closed-circuit refueling system is a compact unit which is installed flush with the existing helicopter filler neck opening. It is an aluminum unit weighing 2.15 pounds, less the nozzle and nozzle adapters, and it extends 4.18 inches into the helicopter tank. The system consists of five units:

1. Helicopter Filler Neck Flange Assembly. This is a one-piece machined unit which has a bar-type female quick-disconnect unit designed to accept the automatic-shutoff nipple assembly. The flange weighs 1.67 pounds.
2. Helicopter Automatic Refueling Shutoff Nipple Assembly.\*\* This assembly is the male connector, which, when inserted into the helicopter-mounted flange assembly, automatically closes the aircraft fuel tank. The nipple is removable to allow conventional refueling. This unit consists of the automatic-shutoff vacuum tube mechanism. A dust cap is provided with a length of 1/16-inch-diameter stainless steel cable which can be attached to the helicopter. The unit weighs 0.48 pound.
3. Automatic-Shutoff Refueling Nozzle Assembly. This assembly is a standard commercial unit with a 1.5-inch adapter provided to

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\*Parts of this section have been extracted from the letter report, "Military Potential Test of Automatic Closed-Circuit Refueling System for UH-1 Helicopter", U. S. Army Aviation Test Board, Fort Rucker, Alabama, dated 7 July 1967.

\*\*Modified by the U. S. Army Aviation Test Board.



increase the inlet diameter to standard military specifications. The vacuum tube is located at the nozzle fuel outlet and is attached to the nozzle vacuum chamber. This tube is connected to the automatic-shutoff closed-circuit nozzle socket by a short length of Teflon tubing. The unit weighs 6.50 pounds.

4. Automatic-Shutoff Nozzle Socket Assembly. The automatic-shutoff nozzle socket assembly is the female coupling of the nipple assembly and includes the vacuum tube mechanism. The socket is installed at the outlet section of the nozzle and is connected to the nozzle vacuum system by a short length of Teflon tubing. The socket assembly incorporates a locking device which has a quick-disconnect/connect feature. The socket is supplied with a dust cap to prevent contamination. The socket weighs 1.88 pounds.
5. Conventional Refueling Nipple Assembly. The conventional refueling nipple assembly is a straight 10.875-inch-long tube with a male open-end quick-disconnect nipple unit. This tube is inserted into the nozzle socket assembly to allow conventional refueling. When this nipple assembly is inserted into the nozzle socket, the system is no longer automatic, and the nozzle must be operated manually. The unit weighs 0.90 pound.

When the nozzle and socket assembly are mated for refueling, the following events occur:

- Event 1: Probe (H) depresses valve (I), which places orifice (J) into chamber (K) and establishes a free passage (B) in the male member, a free passage (A) in the female member, and a through passage (N) in the nozzle. (See Figures 7 and 8.)
- Event 2: Movable valve (E) is depressed by stationary probe (F), and direct fuel flow is established from the nozzle to the tank through chambers (C) and (D). (See Figures 7 and 9.)
- Event 3: When the fuel level in the aircraft tank reaches the level of the entrance of the air passage tube (B), the fuel causes a blockage in the air passage line; thus, a vacuum is created in this line and in the nozzle air chamber (Nc). (See Figure 8.) This vacuum then causes the valve of the nozzle to actuate to the closed position and thus shut off the flow of fuel.

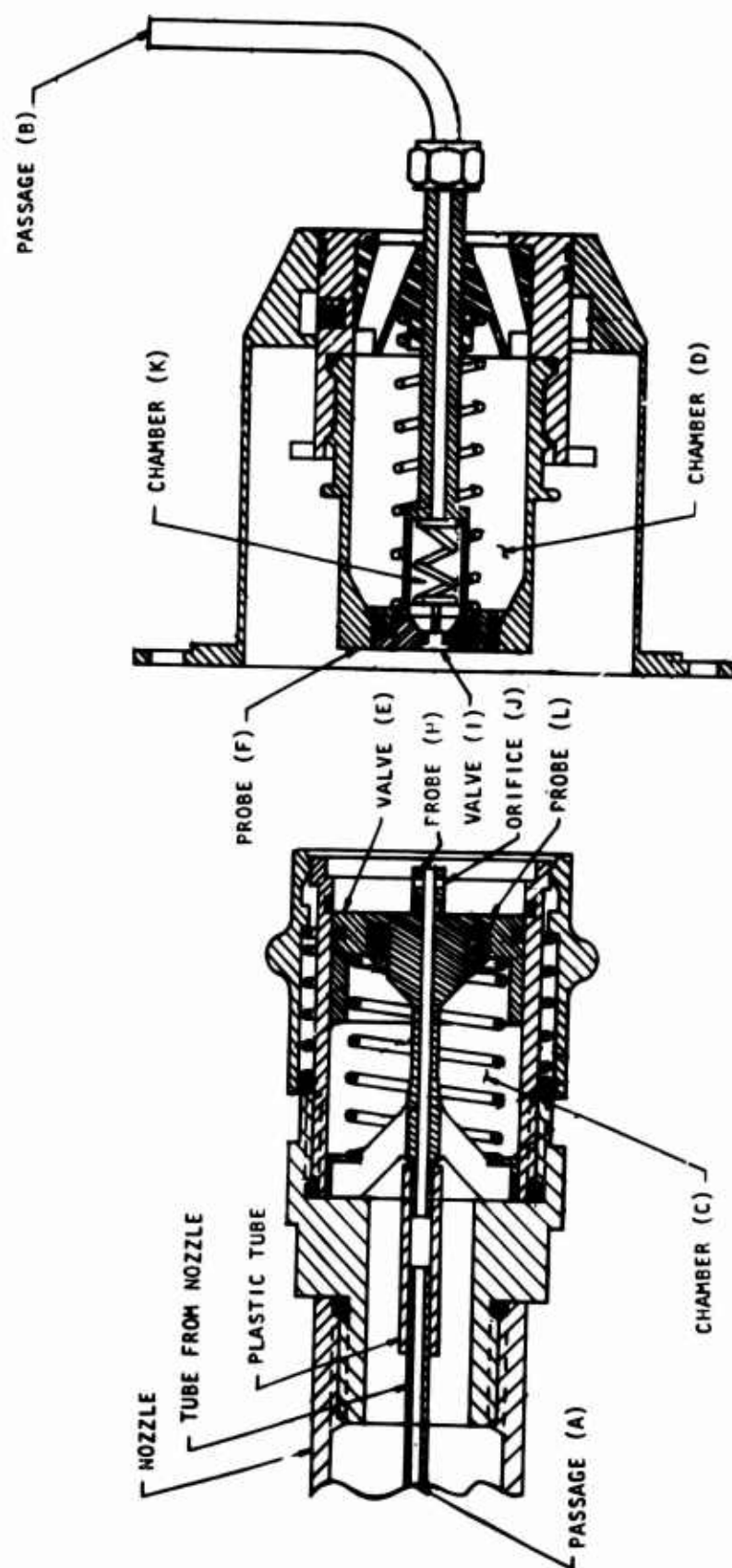


Figure 7. Automatic Closed-Circuit Refueling System.

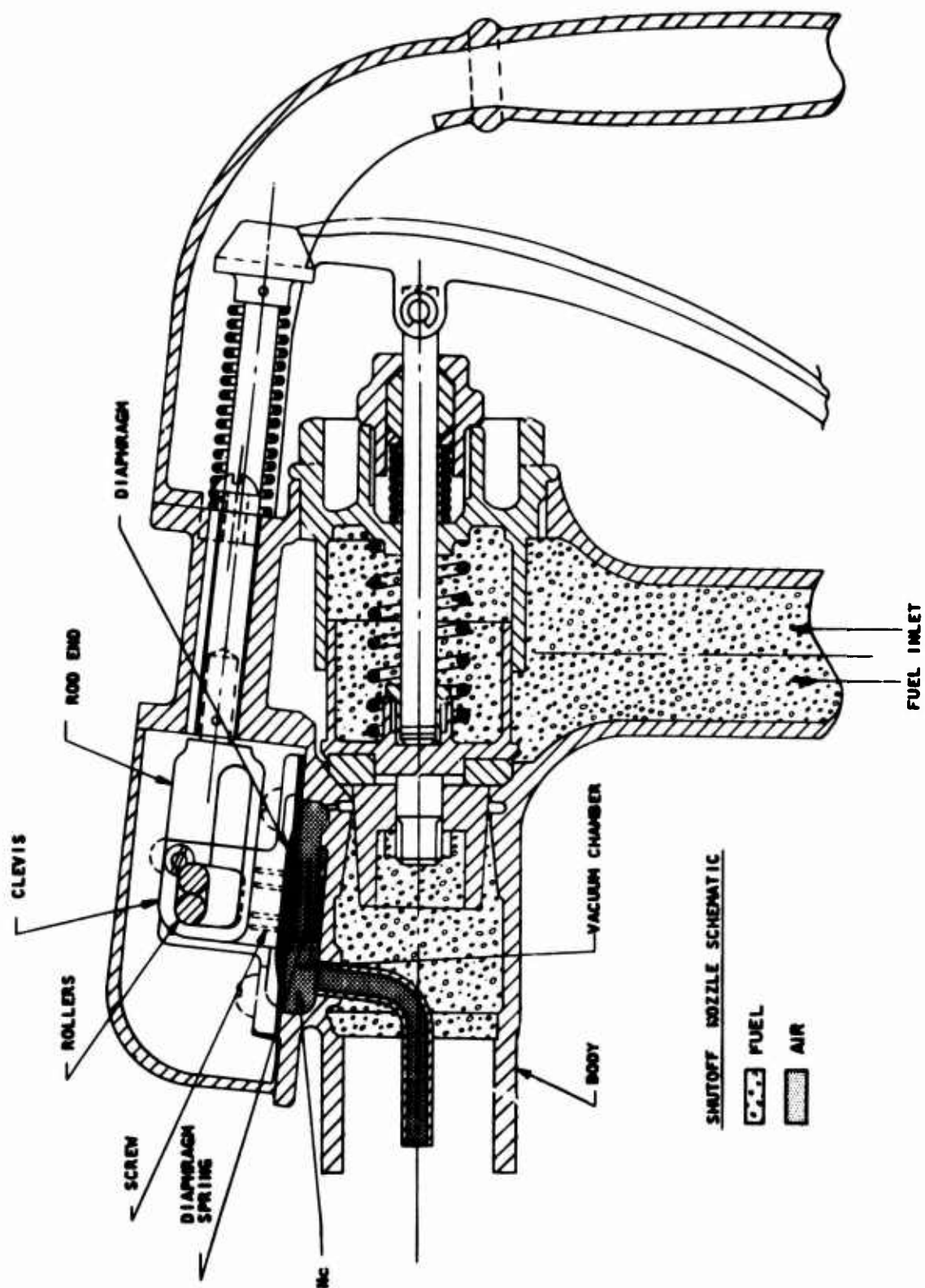


Figure 8. Schematic of Nozzle.

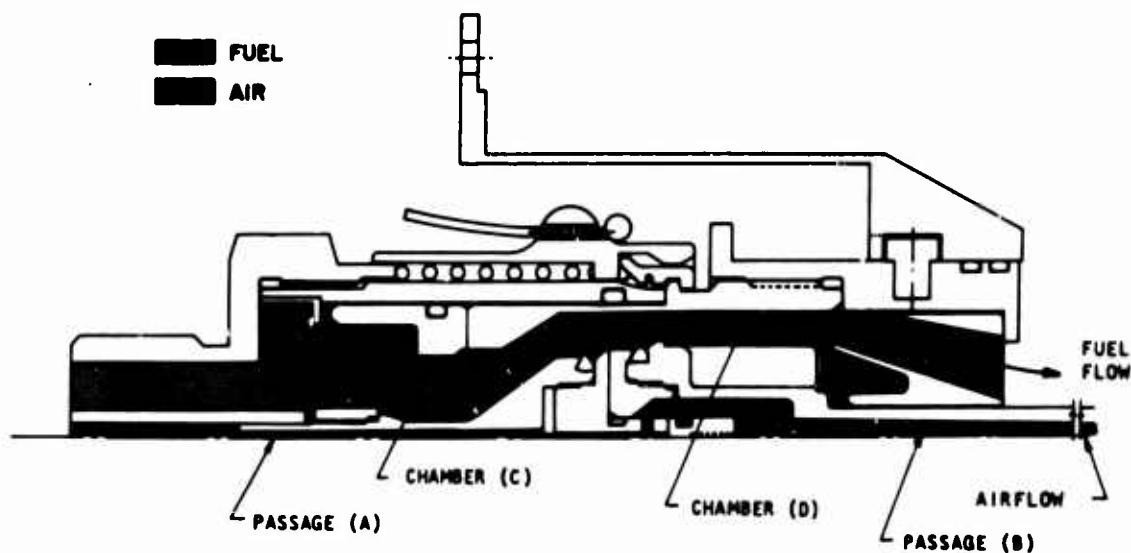


Figure 9. Schematic of Fuel Flow.

#### Quality Assurance Acceptance Tests

Ten aircraft adapters and three nozzle adapters which were fabricated in accordance with USAAVLABS sketches were purchased for the military potential tests at a cost of \$2450. This total purchase price included the cost of tooling and delivery of 10 aircraft adapters and 3 nozzle adapters. The purchase price of the automatic-shutoff nozzle was \$150. Excluding tooling costs, the price per aircraft adapter was \$100 and the cost per nozzle with adapter was \$200.

Quality assurance acceptance tests of the units were conducted at USAAVLABS. Minor deficiencies noted were as follows:

1. Seal failure
2. Automatic-shutoff failure
3. Loss of conventional refueling tube

Improperly designed seal grooves caused the seal failures. The seal grooves were modified to correct this deficiency.

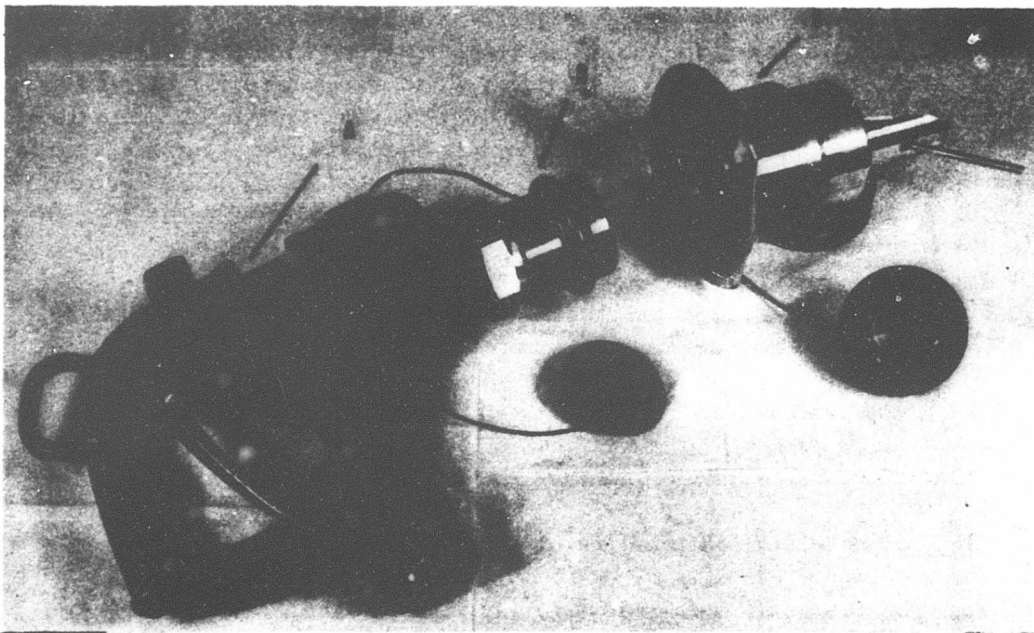
The automatic-shutoff device failed in two modes. During one refueling, the nozzle did not shut off when the fuel tank was full. During several refuelings, the automatic shutoff operated prematurely, that is, before the fuel tank was full. Examination of the mechanism revealed no failed components. A discussion with the manufacturer of the nozzle revealed

that the fuel flow rate had to be held between 15 and 25 gpm. At flow rates below 15 gpm, the automatic mechanism would not function; at flow rates greater than 25 gpm, the automatic device would operate prematurely. No design changes were made to overcome this undesirable feature. It was decided simply to limit the pumping of fuel to within these levels during the test program. Then, if test results indicated that the system had potential, the undesirable restriction on pumping rates could be overcome during advanced development of the system.

#### Modified Hardware

The modified prototype units were then forwarded to Fort Rucker for the military potential tests.

Figure 10 shows the hardware as delivered to the U. S. Army Aviation Test Board. Figure 11 shows the adapter tube which would be used with the nozzle if the aircraft were not equipped for closed-circuit system



**Figure 10. Prototype Automatic-Shutoff Refueling System.**  
(a) Modified Commercial Automatic-Shutoff Nozzle.  
(b) Modified Dry-Break Coupling Attachment.  
(c) Aircraft Adapter.

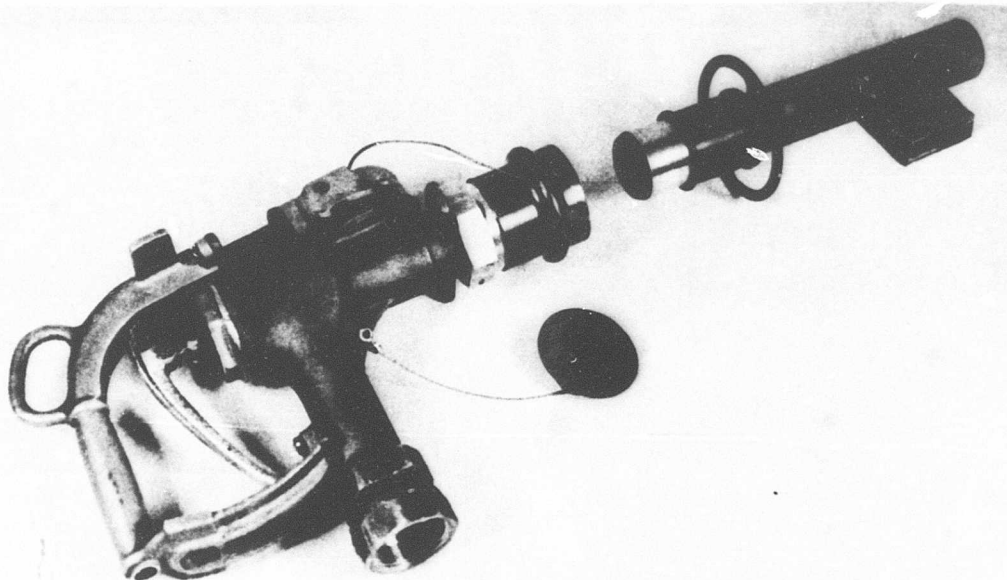


Figure 11. Automatic Nozzle With Adapter for Conventional Refueling.

refueling. Aircraft adapter parts are shown in Figure 12. Figure 13 shows the adapter installed on a UH-1 helicopter. The adapter is mounted flush with the aircraft skin, so that clearance is provided for the aircraft door. Figure 14 shows the nozzle mated with the adapter and ready for refueling. Figure 15 shows the adapter nipple being removed preparatory to refueling in the conventional manner.

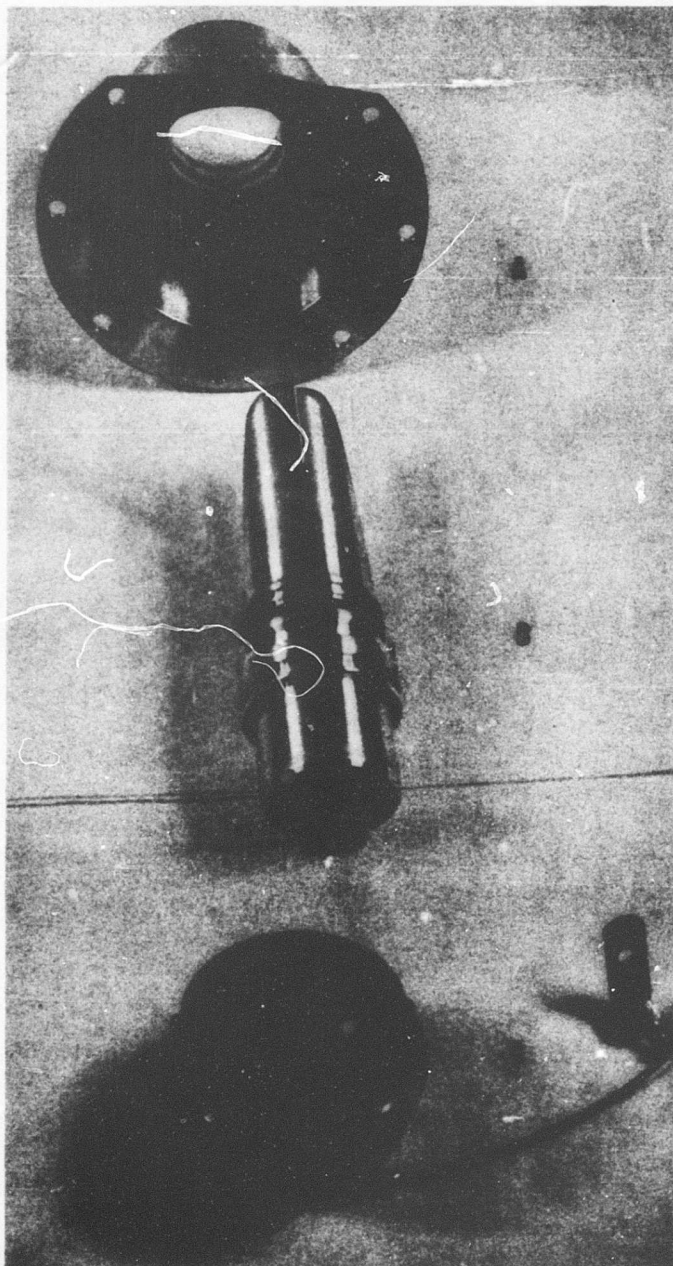
### PROCEDURE

The U. S. Army Aviation Test Board conducted the military potential tests of the closed-circuit refueling system for UH-1 helicopters at Fort Rucker, Alabama, during the period 17 November 1966 through 24 April 1967.

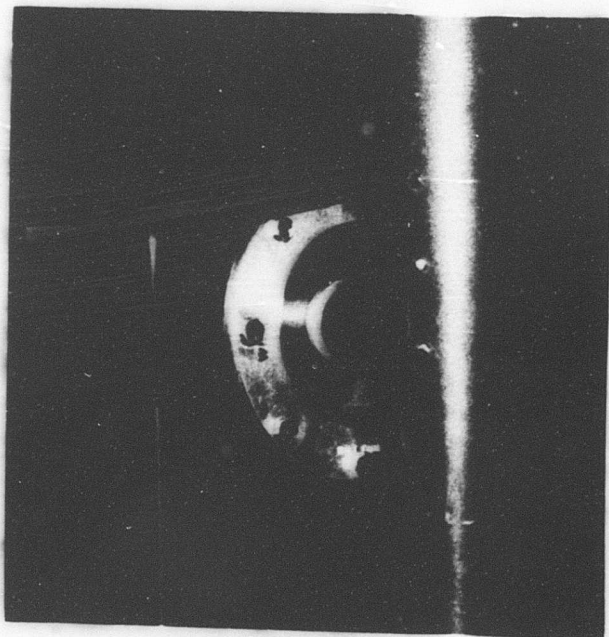
### Physical Characteristics

The closed-circuit refueling system was measured, weighed, and photographed; significant physical characteristics were noted.

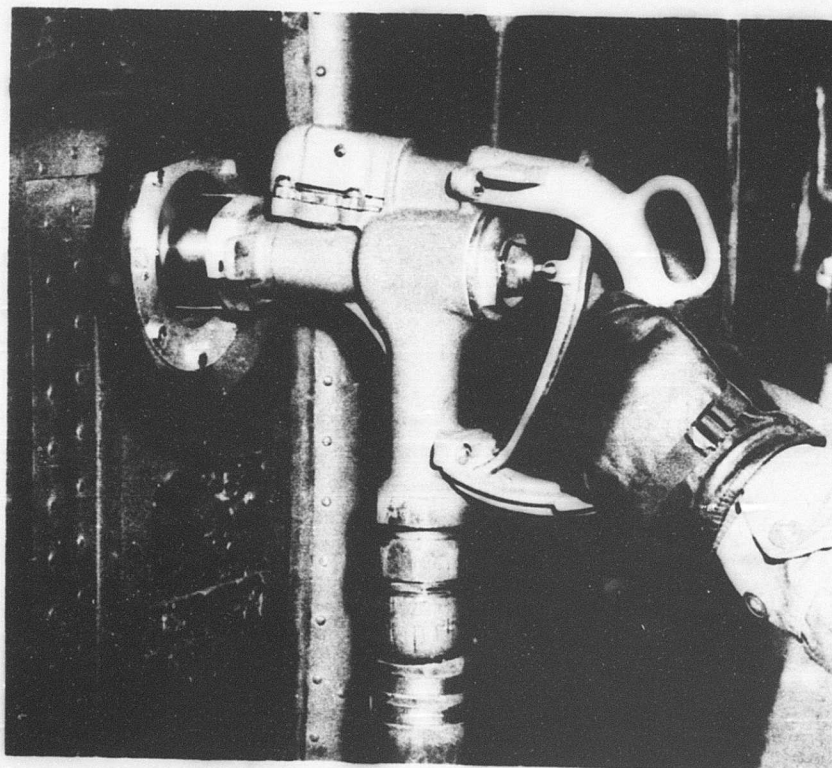




**Figure 12. Aircraft Adapter Parts.**  
**(a) Helicopter Flange Adapter.**  
**(b) Removable Automatic-Shutoff Nipple Assembly.**  
**(c) Automatic-Shutoff Nipple Dust Cap.**



**Figure 13. Aircraft Adapter Installed.**



**Figure 14. Adapter and Nozzle Mated for Refueling.**



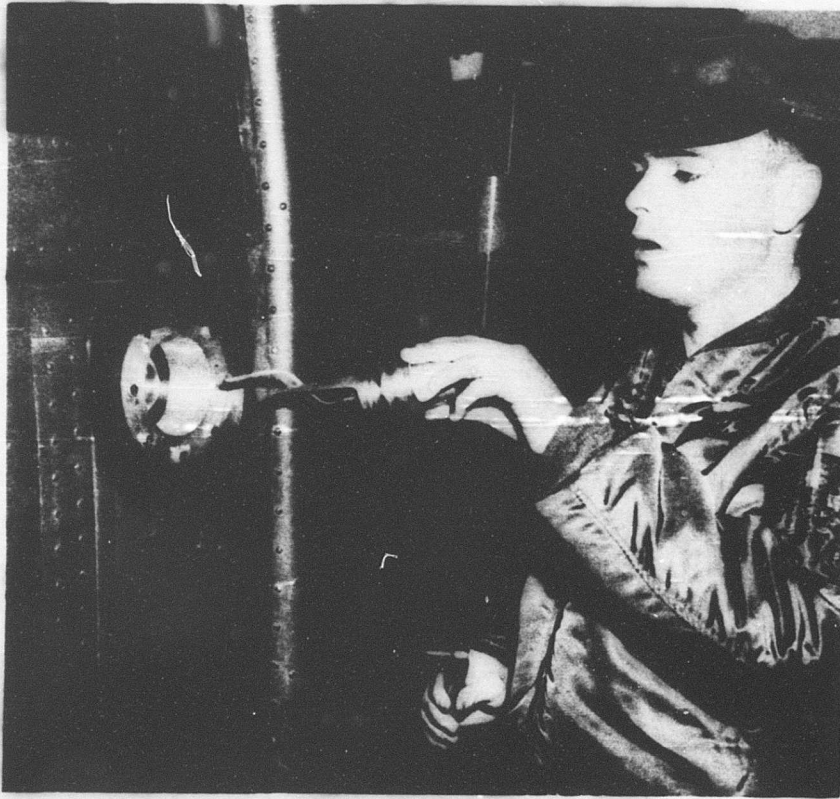


Figure 15. Adapter Nipple Removed.

### Installation

The test system was installed on UH-1B, -1C, and -1D helicopters. The refueling nozzle assembly was installed on a standard Army 1200-gallon tanker. One Single Rotor Turbine Observation Utility Helicopter Repairman, using an aircraft general mechanics tool set, accomplished the installation. The procedures, man-hours, skills, and tools required to install the test system were recorded. The installation procedures furnished by USAAVLABS in their plan of test were evaluated.

### Operational Suitability

The test helicopters were refueled using the test system. Refueling was accomplished with engines and rotors running. The time to refuel using the conventional system was compared with that using the closed system.

Nozzle pressure in psi versus flow rate in gpm was determined from 10 gpm through 50 gpm in increments of 10 psi. The maximum flow rate was determined. The automatic shutoff was tested at various nozzle pressures.

Visual inspections were conducted for fuel leakage during connect and disconnect operations.

Quick breakaway from the refueling hose by means of helicopter lift-off was tested. The cable for quick disconnect of the automatic-shutoff nozzle socket assembly was attached to one end of a lanyard. The other end of the lanyard was attached to a stake driven in the ground.

The automatic nozzle shutoff was tested to ensure that fuel tank capacity was not exceeded.

The unit was tested for contamination by completing 20 operations in a sand pit. Samples were taken before and after each operation to determine the amount of contamination that entered the system.

### Maintainability and Reliability

Maintainability and reliability data were recorded during other test operations. No maintenance package was furnished with the system. Required maintenance was performed by aircraft maintenance personnel using organizational tool sets.

Specific areas evaluated were: safety factors, ease of maintenance, human factors, fault isolations, scheduled and unscheduled maintenance, repair parts usage, mean time between failures (MTBF), and mean time to repair (MTTR).

A refueling flange was installed in a 55-gallon drum. A 1200-gallon tanker was equipped with the refueling nozzle so that the drum could be fueled and defueled with the refueling pump on the tanker. The procedure used was to connect, fill, disconnect, and defuel.

## RESULTS

### Physical Characteristics

The dimensions and weights of the system components are shown in Table I.

TABLE I. DIMENSIONS AND WEIGHTS OF SYSTEM COMPONENTS					
	Length (in.)	Width (in.)	Height (in.)	Weight (lb)	Volume (cu ft)
Flange Assembly	4.18	5.75	5.75	1.67	0.079
Shutoff Nipple Assembly	6.75	2.25	2.25	0.48	0.008
Shutoff Nozzle Assembly	11.25	4.00	10.00	6.12	0.240
Nozzle Socket Assembly	4.00	3.00	3.00	1.88	0.020
Conventional Nipple Assembly	10.87	4.00	1.26	0.90	0.409

### Installation

The procedures and time required for installation are shown in Table II.

TABLE II. INSTALLATION TIME AND PROCEDURES	
	Time (man-minutes)
Detach existing flange from helicopter	2
Install closed-circuit flange on helicopter	3
Remove standard nozzle from refueling hose	2
Install automatic-shutoff nozzle of refueling hose	2
TOTAL	9

The following installation procedures furnished by USAAVLABS were satisfactory:

1. Detach the existing fuel cap flange by removing the flange attaching bolts. Remove and destroy the existing O-ring seal located between the tank flange and tank adapter and replace this seal with a new one. Install the closed-circuit flange and body assembly in the tank filler neck opening with the original bolts removed.
2. Remove the standard refueling nozzle from the refueling vehicle, and replace this nozzle with the automatic-shutoff nozzle.

### Operational Suitability

The results of the time comparison of the conventional system and the closed-circuit system, on the basis of 20 refueling operations for each, are:

#### Conventional System (Average)

Time: 2 min 46 sec      Gallons Pumped: 77

#### Automatic Closed-Circuit System (Average)

Time: 2 min 20 sec      Gallons Pumped: 85

Actual fueling time was 5 to 7 percent less with the closed system.

The pressures and flow rates are shown in Table III. The table also indicates whether automatic shutoff was achieved.

TABLE III. SYSTEM CHARACTERISTICS		
Line Pressure (psi)	Flow Rate (gpm)	Shutoff
2	12	No
7	14	No
8	16	Yes
9	17	Yes
10	20	Yes
20	30	Yes
26	41	Yes
27	42	Yes
36	50	Yes
38	52	Yes
40	52	Yes

Fuel leakage did not occur during the connects and disconnects made during refueling operations.

No failures occurred during the four quick breakaways effected by helicopter lift-off. The only method for quick disconnect and hose nozzle removal was to hover the helicopter and move laterally away from the hose

and the tether stake. The design of the quick-disconnect device precluded random-direction breakaway.

The fuel tank vent system bled off pressure with no problem during refueling.

During refueling of the UH-1B and -1D, automatic shutoff occurred before the tank was filled to capacity because of the accumulation of foam in the tank. After the foam settled, the refueling nozzle was again turned on. The UH-1D took 8 more gallons; the UH-1B, 2 more. The final fuel level in the UH-1D was 7.6 gallons (49.3 pounds\*) above the level that could be achieved using the conventional refueling system; in the UH-1B, it was 9.6 gallons (62.4 pounds\*) over the level with conventional refueling. Premature shutoff did not occur on the UH-1C, because the dome-shaped top of the UH-1C's fuel cell allowed room for the foam. The amount of fuel that could be placed in the UH-1C with the closed-circuit system was 9.6 gallons more than that with the conventional system.

Negligible fuel contamination occurred during the sand pit tests.

#### Maintainability and Reliability

This system enhanced safety because of the reduced risk of fuel contamination and the reduced risk of fire or explosion resulting from ignition of fuel fumes. The only unsafe feature noted during the test existed in the quick-disconnect device on the automatic-shutoff nozzle socket assembly. Although the device did not fail during the test, a straight pull on the cable was required to disconnect the assembly, and the possibility existed that the disconnect cable could break. These factors would present a distinct safety hazard during attempts at emergency breakaways without notifying the ground crew.

No scheduled maintenance was required during the test. Unscheduled maintenance consisted of the replacement of two O-rings and one sensing-tube-to-nipple assembly.

The system was easy to maintain, and faults could be located easily.

The system was considered to be satisfactory from a human factors standpoint.

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\*JP-4 at 6.5 pounds per U. S. gallon.

The cables that retain the nozzle dust caps and the shutoff assembly dust caps were of a lightweight material and were easily frayed and broken. In addition, the eyelet hole in the device that fastens the nipple assembly dust cap to the aircraft was too small. The hole was 1/4 inch in diameter and was required to be attached to a 7/16-inch bolt. The device was locally modified by enlarging the hole so that the device would operate properly.

Maintenance was performed at the organizational level by a Single Rotor Turbine Observation Utility Helicopter Repairman using an organizational tool kit, with the exception of one special tool. This special tool, locally fabricated, was needed to replace the O-ring and the sensing-tube-to-nipple assembly.

Three failures occurred in 2,079 aircraft operating hours, resulting in an MTBF of 693 hours. During this period, 548 refuelings were performed. No failures occurred during the 3,500 refueling operations using the 55-gallon drum. The failure rate for the entire test was one failure per 1,349 refueling operations.

The three failures required a total of 1 hour to repair, resulting in an MTTR of 0.33 hour.

#### Deficiencies

The deficiencies discovered during the test are shown in Table IV.

TABLE IV. DEFICIENCIES OF CLOSED-CIRCUIT SYSTEM AND SUGGESTED CORRECTIVE ACTION	
Deficiency	Suggested Corrective Action
No maintenance package was furnished.	Provide maintenance package consisting of technical manuals and parts list in Army format; also provide spare parts.
Special tool was not provided to remove O-rings and sensing-tube-to-nipple assembly.	Provide special tool for this purpose.

TABLE IV - Continued	
Deficiency	Suggested Corrective Action
The quick-disconnect device presented a safety hazard in that a straight pull on the disconnect cable was required for breakaway.	Redesign quick-disconnect so that breakaway occurs regardless of the angle of pull.
The cables that retain the nozzle dust caps and shutoff nipple assembly dust caps were easily frayed and broken.	Use heavier cable, covered with plastic.
The eyelet hole in the device that retains the nipple assembly dust cap to the aircraft was too small, and the material of which the device is made was too lightweight.	Provide device with 7/16-inch hole. Construct device of heavier material.
The aluminum sensing-tube-to-nipple assembly was easily broken.	Construct assembly of steel.
Foam buildup caused premature shutoff.	None.

## CONCLUSIONS

Based on the results of the military potential tests, the U. S. Army Aviation Test Board concluded that the automatic closed-circuit refueling system has military potential and that, by using the test system, UH-1( ) helicopters can be refueled more safely with the engines operating.

## RECOMMENDATIONS

The U. S. Army Aviation Test Board recommended that:

1. Development of the automatic closed-circuit refueling system for Army use be continued.

2. The deficiencies found in the system be corrected as technically and economically feasible.
3. After further development, a service test of the automatic closed-circuit refueling system be conducted.



### COMPATIBILITY STUDY

Concurrent with the military potential tests and at the request of the UH-1 project manager, the manufacturer of the UH-1 helicopter conducted a compatibility study of the closed-circuit automatic refueling system on the UH-1 aircraft. The study indicated that the systems were compatible, subject to modifications to overcome certain characteristics which the UH-1 manufacturer considered to be adverse:

1. Insufficient fuel expansion space remaining after refueling.
2. Possibility of rupture of the fuel bladder and/or damage to surrounding structure in the event of automatic-shutoff failure.
3. Interference between fuel cell bladder and closed system aircraft adapter on the UH-1D helicopter.

A study of these problems was made. It was determined that problems 1 and 3 could be eliminated by reshaping the fuel level sensing tube on the adapter nipple assembly, and that problem 2 could be overcome by modifying the design to improve the reliability of the automatic-shutoff nozzle. These deficiencies will be corrected in any further development of the system.

## CONCLUSIONS

It is concluded that:

1. The automatic closed-circuit refueling system has military potential.
2. Helicopter refueling can be accomplished with rotors and engines operating without the risk of fuel contamination and fire hazard.
3. The automatic closed-circuit refueling system is economical and practical. Retrofit may be accomplished within 15 minutes without the use of special tools or training (touch time - 9 minutes).
4. The reliability of the automatic closed-circuit refueling system is high.
5. The effectiveness of the helicopter as an assault vehicle can be significantly increased if the automatic-shutoff closed-circuit refueling system is adopted.

## RECOMMENDATIONS

It is recommended that:

1. The U. S. Army conduct a program for the full development of an automatic-shutoff closed-circuit refueling system.
2. The U. S. Army procure a limited quantity of automatic-shutoff closed-circuit refueling systems for use in Southeast Asia to determine their effectiveness in field service.

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13. ABSTRACT An in-house program was conducted by the U. S. Army Aviation Materiel Laboratories to derive a method for rapid refueling of Army helicopters. The objective was to devise a system which would permit refueling of helicopters while engines and rotors were operating without the risk of fuel contamination or the hazard of fire. A closed system utilizing a dry-break coupling between fuel hose nozzle and aircraft was deemed to offer potential.  Experimental models were fabricated and tested and modifications were made to the models in areas where test results indicated that deficiencies existed. Tests and modifications continued until design characteristics for a prototype model were finalized. Design characteristics are as follows: (1) automatic-shutoff device, (2) quick-connect/disconnect dry-break coupling between aircraft adapter and nozzle, (3) conventional refueling capability, (4) simplified system for field retrofit.  Ten prototype units were fabricated for military potential test purposes. The tests, which were conducted by the U. S. Army Aviation Test Board at Fort Rucker, Alabama, showed that the automatic-shutoff closed-circuit refueling system has military potential and will meet the program objective.  It is concluded that the effectiveness of helicopters as assault vehicles can be improved through the use of this system.		

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